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(באנגלית) (English) PHASED ARRAY ANTENNA FOR INDOOR APPLICATION

ממציאים: שי וסר, נתן בלאונשטיין ומרדכי גזית
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מערך פאזי של אנטנות לשימושים באזור סגור

PHASED ARRAY ANTENNA FOR INDOOR APPLICATION

ממציאים:
שי וסר, נתן בלאונשטיין ומרדכי גזית

FIELD OF THE INVENTION

The present invention generally relates to a phased array antenna assembly, adapted for reducing severe radiation hazards to the human body. This antenna assembly is useful for transmitting and receiving signals while taking into account the indoor electromagnetic field strength. The present invention generally specifically relates to a phased array antenna assembly comprising the following three components: micro-strip small-size antenna, switching device and a controller.

BACKGROUND OF THE INVENTION

Momentum gained in the last decade including the introduction of mobile vehicular communication systems is being fully exploited in an international effort to realize the personal communication services (PCS) of tomorrow. In the envisioned PCS, each subscriber carries a pocketsize communication with all associated personal telephone number. An intelligent global network locates the individual and supervises two-way wireless transmissions which may involve speech, data, fax, and, video streams.

The most important aspect of PCS is wireless communication inside buildings, where people spend most of their time. In a typical wireless indoor application, transmission takes place over a radio link ranging from a few meters to a few tens of meters. Indoor radio propagation, whoever, is more complicated than transmission between an earth station and a spaceship millions of kilometers away. Signals received inside a building suffer from serious distortions caused by multipath dispersion, and are usually severely attenuated. The channel is dynamic, with its properties changing over space (motion of the portable unit itself) and over time (motion of people and objects around the wireless potable unit). Detailed characterization of the propagation medium is essential in successful design of indoor communication systems.

In a typical indoor portable wireless system, a basestation with a fixed antenna (AP) is installed in an elevated position, communicates with a number of portable/fixed radios (Stations) inside the building. Due to reflection and scattering of radio waves by structures inside a building, the transmitted signal most often reaches the receiver by

more than one path, resulting in a phenomenon known as multipath fading. The signal components arriving from indirect paths and the direct path (if it exists) combine and produce a distorted version of the transmitted signal. In narrow-band transmission, the multipath medium causes fluctuations in the received signal envelope and phase. In wide-band pulse transmission, on the other hand, the effect is to produce a series of delayed and attenuated pulses (echoes) for each transmitted pulse. This is illustrated in Fig. 1, where the channel's responses at two points in the three-dimensional space are displayed. Figure 1A presents a point with low delay spread while Fig. 1b presents a point with a larger delay spread. Both analog and digital transmissions suffer from severe attenuation by the intervening structure. The received signal is further corrupted by other unwanted random effects: noise and co-channel interference.

Multipath fading seriously degrades the performance of communication systems operating inside buildings. Unfortunately, one can do little to eliminate multipath disturbances. However, if the multipath medium is well characterized, transmitter and receiver can be designed to "match" the channel and to reduce the effect of these disturbances. Detailed characterization of radio propagation is therefore a major requirement for successful design of indoor communication systems.

Propagation of radio waves inside a building is a highly complicated process. The impulse response approach described here can be used to characterize the channel. A study of the literature shows that the number of multipath components in each impulse response profile, N, is a random variable. Mean value of N is different for different types of buildings. The path variable sequences $\{a_k\}$, $\{t_k\}$, θ_k for every point in space are random sequences. The mean and variance of the distribution of a_ks are also random variables due to large-scale in homogeneties in the channel over large areas.

Adjacent multipath components of the impulse response profile are dependent. A standard Poisson hypothesis is inadequate to describe the arrival-time sequences. Adjacent amplitudes are likely to have correlated fading for high resolution measurements since a number of scattering objects that produce them may be the same. Phase components for the same profile, however, are not correlated since at

frequencies of interest their relative excess range is much larger than a wavelength. The amplitude sequence and the arrival-time sequence are correlated because later paths of a profile go through multiple reflections and hence experience higher attenuation.

The impulse response profiles for points that are close in space are correlated since the structure of the channel does not change appreciably over very short distances. Spatial correlation govern the amplitudes, the arrival-times and the phases, as well as the mean and variance of the amplitudes. There are small-scale local changes in the channel's statistics and large-scale global variations due to shadowing effects and spatial non-stationarities.

Path loss in an indoor environment is very severe most of the time. It is also very dynamic, changing appreciably over short distances. Simple path loss rules are successful in describing the mobile channel, but not the indoor channel.

The parameters of the channel have great dependence on the shape, size and construction of the building. Variations with frequency are also significant.

In its more general form the channel is non-stationary in time. Temporal variations are due to the motion of people and equipment around both antennas.

Any realistic channel model should consider the above factors. Furthermore, it should derive its parameters from actual field measurements rather than basing them on simplified theory.

A known and a convenient model for characterization of the indoor channel is the discrete-time impulse response (i.e., DTIR) model. In this DTIR model the time axis is divided into minor intervals called "bins". Each bin is assumed to contain either one multipath component, or no multipath component. Possibility of more than one path in a bin is excluded. A reasonable bin size is the resolution of the specific measurement since two paths arriving within a bin cannot be resolved as distinct paths. According to the DTIR model, each impulse response is described by a sequence of "0"s and "1"s (the path indicator sequence), where a "1" indicates

presence of a path in a given bin and a "0" represents absence of a path in that bin. To each "1", an amplitude and a phase value are associated.

The advantage of this model is that it greatly simplifies any simulation process. It has been used successfully in the modeling and the simulation of the mobile-radio propagation-channel. Analysis of system performance is also easier with a discrete-time model, as compared to a continuous-time model.

When a single unmodulated carrier (constant envelope) is transmitted in a multipath environment, due to vector addition of the individual multipath components, a rapidly fluctuating CWS envelope is experienced by a receiver in motion. To deduce this narrow-band result from the above wide-band model we let s(t) of (4) equal to 1. Excluding noise, the resultant CWS envelope R and phase φ for a single point in space are thus given by equation 1:

$$\mathrm{R}e^{j\varphi} = \sum_{k=0}^{\infty} a_k e^{j\theta_k} \tag{1}$$

Sampling the channel's impulse response frequently enough, one should be able to generate the narrow-band CWS fading results for the receiver in motion, using the wide-band impulse response model.

The impulse response approach described in the previous section is supplemented with the geometrical model of Fig. 2. The signal transmitted from the base reaches the portable radio receivers via one or more main waves. These main waves consist of a line-of-sight, i.e., LOS (1) ray and several rays reflected (2) or scattered by main structures such as partitions (3), outer walls, floor (4), ceilings, etc. The LOS wave may be attenuated by the intervening structure to an extent that makes it undetectable. The main waves are randomized upon arrival in the local area of the portable. They break up in the environment of the portable due to scattering by local structure and furniture. The resulting paths for each main wave arrive with very close delays, experience about the same attenuation, but have different phase values due to different path lengths. The individual multipath components are added according to

their relative arrival times, amplitudes, and phases, and their random envelope sum is observed by the portable. The number of distinguished paths recorded in a given measurement, and as a given point in space depends on the shape and structure of the building, and on the resolution of the measurement setup.

The impulse response profiles collected in portable site *i* and portable site *j* of Fig. 3 are normally very different due to differences in the intervening (base to portable) structure, and differences in the local environment of the portables.

Variations in the statistics are now described. Let

$$X_{ijk}(i = 1,2,\ldots,N; j = 1,2,\ldots, M; k = 1,2,\ldots,L) \quad (2)$$

be a random variable representing a parameter of the channel at a in the three dimensional space. For example, X_{ijk} may represent amplitude of a multipath component at a fixed delay in the wide-band model, amplitude of a narrow-band fading signal, the number of detectable multipath mean excess delay or delay spread, etc. The index k in X_{ijk} numbers spatially adjacent points in a given portable site of radius 1-2m. These points are very close (in the order of several centimeters or less). The index *j* numbers different sites with the same base-portable antenna separations, and the index *i* numbers groups of sites with different antenna separations.

With the above notations, there are three types of variations in the channel. The degree of these variations depends on the type of environment, distance between samples, and on the specific parameter under consideration. For some parameters, one or more of these variations may be negligible.

It is acknowledged that for small-scale variations, a number of impulse response profiles collected in the same "local area" or site are grossly similar since the channel's structure does not change appreciably over short distances. Therefore, impulse responses in the same site exhibit only variations in details. With fixed *i* and *j*, $X_{ijk}(k = 1,2,\ldots, L)$ are correlated random variables for close values of k . This is equivalent to the correlated fading experienced in the mobile channel for close sampling distances.

It is further acknowledged that for mid-scale variations, this is a variation in the statistics for local areas with the same antenna separation. As an example, two sets of data collected inside a room and in a hallway, both having the same antenna separation, may exhibit great differences. If μ_{ij} denotes the mathematical expectation of X_{ijk} (i.e. $\mu_{ij} = E_k\ (X_{ijk})$, where E_k denotes expectation with respect to k), then for fixed i, μ_{ij} is a random variable. For amplitude fading, this type of variation is equivalent to the shadowing effects experienced in the mobile environment. Different indoor sites correspond to intersections of streets, as compared to mid-blocks.

It is lastly acknowledged that for large-scale variations, the channel's structure may change drastically, when the base to portable distance increases, among other reasons due to an increase in the number of intervening obstacles. As an example, for amplitude fading, increasing the antenna separation normally results in an increase in path loss. Using the previous terminology $\varepsilon\ (d_i)=E_{jk}(X_{ijk})=E_j(\mu_{ij})$ *is* different for different $d_i s$, if X_{ijk} denotes the amplitude, this type of variation is equivalent to the distance dependent path loss experienced in the mobile environment. For the mobile channel ε (d) is proportional to d^{-n}, where d is the base-mobile distance and n *is* a constant.

A comparison between the indoor and the mobile channels is now provided. The indoor and outdoor channels are similar in their basic features: they both experience multipath dispersions caused by a large number of reflectors and scatters They can both be described using the same mathematical model. However, there are also major differences, briefly described in this section.

The conventional mobile channel (with an elevated base-station and low-level mobile/fixed station) is stationary in time and non-stationary in space. Temporal stationary is because signal dispersion is mainly caused by large fixed objects (buildings). In comparison, the effect of people and vehicles in motion are negligible. The indoor channel, on the other hand, is not stationary in space or in time. Temporal

variations in the statistics of the indoor channel are due to the motion of people and equipment around the low-level portable antennas.

The indoor channel is characterized by higher path losses and sharper changes in the mean signal level, as compared to the mobile outdoor channel. Furthermore, applicability of a simple negative-exponent distance-dependent path loss model well established for the mobile channel is not universally accepted for the indoor channel.

Rapid motions and high velocities typical of the mobile users are absent in the indoor environment. The Doppler shift of the indoor channel is therefore negligible.

Maximum excess delay for the mobile channel is typically several microseconds if only the local environment of the mobile is considered, and more than $100\,\mu s$ if reflection from distant objects such as hills, mountains, and city skylines are taken into account. The outdoor rms delay spreads are of the order of several μs without distant reflectors, and 10 to 20 μs with distant reflectors. The indoor channel, in the other hand, is characterized by excess delays of less than one μs and rms delay spreads in the range of several tens to several hundreds of nanoseconds (most often less than 100ns). Therefore, for the same level of inter-symbol interference, transmission rates can be much higher in the indoor environments.

Finally, the relatively large outdoors-mobile transceivers are powered by the battery of the vehicle with an antenna located away from the mobile user. This is in contrast with lightweight portables normally operated close to the user's body. Therefore, much higher transmitted powers are feasible in the outdoors-mobile environment.

SUMMARY OF THE INVENTION

It is the prepuce of the present invention to present a phased array antenna assembly, adapted for reducing severe radiation hazards to the human body. This antenna assembly is useful for transmitting and receiving signals while taking into account the indoor electromagnetic field strength. Said antenna design comprising the following three components: micro-strip small-size antenna, switching device and a controller. Surpassingly and most importantly, the said provided assembly is cost effective in the manner it is adapted for a indoor mass-utilization consisting of low cost materials and components. Additionally, said assembly was provided to radiate a limited electromagnetic field in a minimal measure required for communication.

The said switching device is having a communicating means with said antenna to select between receiving or transmitting modes. In addition, said switching device further having a selecting means for phase shift and the receiving/transmitting frequencies.

The aforementioned controller is adapted to receive inputs from said switching device. It is comprises of coordinating means and a suitable memory. The said coordinating means is adapted to interconnect said switching device with a algorithm-based software. The said memory queue that records the optimal path in each indoor environment to each of the associated nodes to said antenna assembly.

It is also in the scope of the present invention to provide the novel antenna as defined above, wherein the indoor electromagnetic field is located in a closed construction selected from house, apartment, large vehicle, aircraft or ship, industrial space or office and further wherein said closed construction comprising a plurality of openings. Additionally or alternatively, the said closed construction is preferably comprises of obstacles selected from corridors, floors, ceiling, windows, doors or any combination thereof. The openings are preferably selected from corridors, floors, ceiling, windows, doors or any combination thereof, and further wherein said openings are the waveguide slots.

It is further in the scope of the present invention wherein the antenna assembly defined above is characterized by that the path loss (L) of the electromagnetic radiation is calculated by the equation:

$$L_1 = 32.1 - 20\log_{10}(\chi|R_n|) - 20\log\left[\frac{1-(\chi R_n)^2}{1+(\chi R_n)^2}\right] + 17.8\log_{10}(X) + 8.6\log_{10}\left\{-\ln|R_n\chi|\cdot\left(\frac{\pi n}{d}\right)\cdot\left(\frac{X}{\rho_{bn}^{(0)}d}\right)\right\}$$

wherein n is the mode number; *Rn* is the reflection factor for mode number *n*, and *Kn*

$$R_n = \frac{K_n - kZ_{EM}}{K_n + kZ_{EM}}$$

is the wave number for mode n. More specifically, said antenna assembly is potentially characterized by that *Rn* is the reflection factor for mode number *n*, and Kn is the wave number for mode *n*. Additionally or alternatively, the aforementioned antenna assembly is characterized by that antenna creates a main beam lobe, in the manner that Pant = P0 + Pls and Pls = f(L1 *Krssi); wherein P0 – 0 dBm, and Pls – Path loss to the mobile.

It is also in the scope of the present invention wherein an ASIC protocol controls the antenna operation in the manner that the antenna is adapted to fit with any RF protocol. Thus, according to one embodiment oft the present invention, the said ASIC may comprising the algorithm of the following steps: (a) scanning with the first beam for first station; (b) receiving a signal and writing the RSSI; (c) proceeding to next beam direction; (d) getting a max. RSSI or received field strength from said station; (e) calculating the station virtual distance from the said antenna and adjusting the power level to the correct one; (f) registering the obtained RSSI and/or level in a memory, wherein the obtained is associated with the beam direction and with the station ID; and than (g) scanning for a plurality of other stations as required. Preferably, said sequence is additionally consisting the step of proceeding with other receiving and/or transmitting tasks.

According to a particular embodiment of the present invention, the antenna assembly as defined above is characterized by that the calculating step is based on the electromagnetic radiation equation:

$$L_1 = 32.1 - 20\log_{10}(\chi|R_n|) - 20\log\left[\frac{1-(\chi R_n)^2}{1+(\chi R_n)^2}\right] + 17.8\log_{10}(X) + 8.6\log_{10}\left\{-\ln|R_n\chi|\cdot\left(\frac{\pi n}{d}\right)\cdot\left(\frac{X}{\rho_{bn}^{(0)}d}\right)\right\}$$

wherein n is the mode number; Rn is the reflection factor for mode number n, and Kn is the wave number for mode n.

It is also in the scope of the present invention to provide a useful antenna assembly, characterized by that antenna used is a cell-wall socket (CWS). Preferably, according to another preferred embodiment of the present invention, the antenna assembly is adapted to indoor utilizations, wherein either the antenna or its associated clients are interconnected to at last one common network.

It is also in the scope of the present invention wherein the network is implemented in a plurality of closed constructions, in the manner a network of one closed construction is in communication with at least one another network located in at least one other closed construction, and wherein a master operator (e.g., said CWS) is coordinating and/or communicating a plurality of sub-networks.

It is also in the scope of the present invention antenna assembly as defined above, which is preferably characterized by that while one master CWS is busy with an on-going session, selected from any fax, voice, data transaction or any combination thereof, another CWS is used as the coordinating master.

According to another aspect of the present invention, the calling device will identifies itself with its personal identification number (PIN) to the CWS. The free CWS will install the PIN as the calling party number for the exchange. This will cause correct billing of the PIN owner.

It is still according to the main core of the present invention, wherein the aforementioned antenna assembly comprising a phased array antenna. Said antenna comprised of n by m elements with horizontal -- vertical and circular polarization. Hence, the present invention claims for a phased array antenna, as schematically presented in the appended figures, and especially as described and defined in Fig. 9 and Fig. 10.

Lastly, it is according to another aspect of the present invention, a broadband antenna assembly as defined in any of the above is adapted to operate at a frequency within

the band gap of about 900Mhz to about 6Ghz. More particularly, said broadband antenna is adapted to operate at a frequency within the band gap of about 2.4GHz to about 5.8Ghz.

BRIEF DESCRIPTION OF THE FIGURES

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawing, in which

figure 1A schematically presents a point with low delay spread while Fig. 1b presents a point with a larger delay spread;

figure 2 schematically presents multipath from one CWS to 3 Stations;

figure 3 schematically presents a time varying power at different fixed mobiles/stations figure 4 schematically presents stations/mobiles at different locations compared to the AP;

figure 5 schematically presents the ASIC and antenna block diagram;

figure 6 schematically presents presenting an ASIC protocol controls the antenna operation;

figure 7 schematically presents Several CWS nodes form a master to master Ad-hoc network;

figure 8 schematically presents a whole apartment with 3 typical applications;

figure 9 schematically presents a CWS phased array antenna comprised of 4 horizontal radiating elements denoted by the letters A;B;C;D; and

figure 10 schematically presents an indoor phased array antenna.

DETAILED DESCRIPTION OF THE INVENTION

The following description is provided, along all chapters of the present invention, so as to enable any person skilled in the art to make use of said invention and sets forth the best modes contemplated by the inventor of carrying out this invention. Various modifications, however, will remain apparent to those skilled in the art, since the generic principles of the present invention have been defined specifically to provide the antenna assembly as defined and described below.

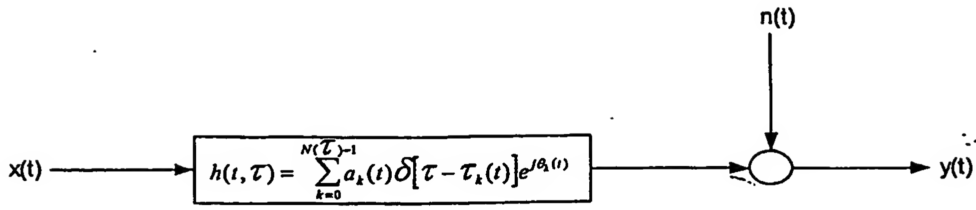
This invention allows any fixed or portable device to adjust the phased array switching antenna beam directly to the source of the communication and calculate the exact needed power to reach the desired destination with the included equations. Today, the solution will cost below 10 dollars in mass production.

The present invention provides a mathematical modeling of the channel. Thus, the novel impulse response approach is hereto presented. The complicated random and time-varying indoor radio propagation channel can be modeled in the following manner: for each point in the three-dimensional space, the channel is a linear time-varying filter with the impulse response given by equation 3:

$$h(t,\tau) = \sum_{k=0}^{N(\tau)-1} a_k(t)\delta[\tau - \tau_k(t)]e^{j\theta_k(t)} \qquad (3)$$

wherein t and τ are the observation time and application time of the impulse, respectively, N(τ) is the number of multipath components, $\{a_k(t)\}$, $\{\tau_k(t)\}$, $\{\theta_k(t)\}$ are the random time varying amplitude, arrival-time, and phase sequences, respectively, and δ is the delta function.

The channel is completely characterized by these path variables. This mathematical model is illustrated below. It is a wide-band model which has the advantage that, because of its generality, it can be used to obtain the response of the channel to the transmission of any transmitted signal s(t) by convolving s(t) with h(t) and adding noise.



The time-invariant version of this model has been used successfully in mobile radio applications. For the stationary (time-invariant) channel, equation (4) is reduced to:

$$h(t) = \sum_{k=0}^{N(\tau)-1} a_k \delta[t - t_k] e^{j\theta_k} \qquad (4)$$

The output y(t) of the channel to a transmitted signal *s(t) is* therefore given by equation 5:

$$y(t) = \int_{-\infty}^{\infty} s(\tau) h[t - \tau] d\tau + n(t)$$

(5)

where *n(t) is* the low-pass complex-valued additive Gaussian noise. With the above mathematical model, if the signal:

$$x(t) = \mathrm{Re}\left\{s(t)e^{j\omega_0 t}\right\} \qquad (6)$$

is transmitted through this channel environment (where s(t) is any low-pass signal and ω_0 is the carrier frequency), the signal

$$y(t) = \mathrm{Re}\left\{\rho(t)e^{j\omega_0 t}\right\} \qquad (7)$$

is received, where instead of the integral we can write equation 8:

$$\rho(t) = \sum_{k=0}^{N-1} a_k s[t - t_k] e^{j\theta_k} + n(t) \qquad (8)$$

In a real-life situation, a portable receiver moving through the channel experiences a space varying fading phenomenon. One can therefore associate an impulse response "profile" with each point in space. It should be noted that profiles corresponding to points close in space are expected to be grossly similar because principle reflectors and scatters, which give rise to the multipath structures, remain approximately the same over short distances.

<u>The Indoor Electromagnetic Equations</u>

Thus, most surprising, a novel and most effective micro-strip small-size and low-cost phased array antenna design is provided by the present invention. Said antenna design, which takes into account the indoor electromagnetic field strength is hence hereto presented. The normal house, apartment or office is divided into areas that are similar to a waveguide. The doors and windows are the waveguide slits. The path loss is calculated with the following new equations (9-10):

$$L_1 = 32.1 - 20\log_{10}\left(\chi\left|R_n\right|\right) - 20\log\left[\frac{1-(\chi R_n)^2}{1+(\chi R_n)^2}\right] + 17.8\log_{10}(X) + 8.6\log_{10}\left\{-\ln\left|R_n\chi\right|\cdot\left(\frac{\pi n}{d}\right)\cdot\left(\frac{X}{\rho_{bn}^{(0)}d}\right)\right\} \quad (9)$$

wherein n is the mode number; L is the path loss is dB; Rn is the reflection factor for mode number n; and Kn is the wave number for mode n.

$$R_n = \frac{K_n - kZ_{EM}}{K_n + kZ_{EM}} \quad (10)$$

The antenna creates a main beam lobe that has only the right amount of field strength that is calculated by (11):

Pant = P0 + Pls (11)

Pls = f(L1 *Krssi)

wherein: P0 – 0 dBm (i.e, 1 mWatt/50 Ohm) and Pls – Path loss to the mobile.

In this way the antenna is radiating only to the desired direction and not polluting the whole space with unnecessary radiation. Secondly, the radiated power is always the

only power that is needed to get to the certain mobile or fixed device and not more. This directed power is hence provided in order to reduce the human body exposure to EM radiation.

ASIC Protocol

Fig. 5 presents the ASIC and antenna block diagram. The ASIC includes the interfaces, processor and flash memory wherein the specific software for the antenna-switching algorithm resides. Flash Memory is referred along the present invention as a variant on EEPROMs where banks of the chip are erased at once. This type of chip has become popular for computer ROMs, offering "easy" field reprogramming. The term ASIC is referred to the known Application-Specific Integrated Circuit. The terms ARM or NEO are referring to any commercial available microprocessor useful also for computing devices. Lastly, the term MAC (Media Access Control) address is referring a unique hardware number of a device.

Reference is made now to Fig. 6, presenting an ASIC protocol controls the antenna operation. The ASIC and the antenna are adapted to fit with any RF protocol. A block diagram of the ASIC and the antenna are shown in the following block diagram:

The ASIC sends a control word to change the beam direction to the RF antenna head when the channel is not the optimum one and in case of active scanning for a new mobile/or fixed station.

The ASIC performs the following MBF algorithm:

1. Scan with the first beam for first station;
2. If receives a signal, write the RSSI;
3. Go to next beam direction;
4. Get max. RSSI or received field strength from that station;
5. Calculate the station virtual distance from the CWS using the electromagnetic equations as defined above, preferably in eq. (9);
6. Adjust the power level to the correct one;
7. Register in a table, the beam direction associated with that station ID;
8. Scan for next station;
9. After scan complete, proceed with other Rx/Tx tasks.

It is acknowledged in this respect that the smart antenna as defined in paragraph (e) is preferably a cell-wall socket (CWS) product. Hence, the said CWS is a wall-installed unit, comprising the element as defined in any of the above.

Wireless Pico Net Master to Master Ad-hoc Association:

The present invnetion generaly relates to any indoor utilizations, wherein the indoor electromagnetic field radiated by either the aforementioned antenna or any of its clients is located in a closed construction selected from house, apartment, large vehicle, aircraft or ship, industrial space or office, and further wherein said closed construction comprising a plurality of openings. It is acknowledged in this respect that either the antenna and its associated clients are interconnected to a common network, denoted herby by the short term 'network'. Reference is hence made to figure 7, schematically presenting several CWS nodes form a master to master Ad-hoc network.

It is further in the scope of the present invention wherein said network is implemented in a plurality of closed constructions, as defined above, in the manner a network of one closed construction is to be in communication with at least one another network located in at least one other closed construction. A master CWS is coordinating and/or communicating those sub-netowrks. Thus, said master CWS comprises of a plurality of master CWS connections, hereto denoted in the present invention in the term "Trunk On Demand" (i.e., TOD).

The TOD feature is required in case that one master CWS is busy with an on-going session. A session can be selected from any fax/voice/data transaction. The TOD feature is in effect only if there is another master CWS in the transmission range of the original master CWS. This other master CWS can be a second line in the same house, a close neighbor in the apartment above or below or another repeater CWS. The collection of close range connected master CWSs comprises the campus network. Any call/transaction will hop from one busy cell to the next looking for the first non-busy twisted pair towards the exchange. The calling device will identifies itself with its personal identification number(PIN) to the CWS. The free CWS will install the PIN as the calling party number for the exchange. This will cause correct billing

of the PIN owner. Reference is hence made to Figure 8 showing a CWS nodes call routing.

The CWS units that are based on the propagation model that as defined above and the smart antenna as similarly defined above will be installed in the walls of the building. The CWS nodes will detect each other and compose the indoors wireless network. If one of the units will be a CWS bridge then the network will have a way to communicate with the outside world as shown in figure 8. The smart antenna will increase this range and the link will be able to penetrate walls. In order to cover a whole apartment or a building with a pico-cell based CWS nodes we need to place a node every several tens of meters such that each CWS AP can communicate with at least one other CWS. A whole apartment with 3 typical applications is shown in figure 8. The applications are: cellular call is route towards CWS from the car, printing from a laptop in the living room, and a refrigerator with an embedded internet enabled device. The CWS AP Master to Master nodes connections are marked in red. The end points are marked with blue links.

Reference is made now to Fig. 9, presenting a CWS phased array antenna comprised of 4 horizontal radiating elements denoted by the letters A;B;C;D;. The crossed circles represent hybrids and the plain circles represent phase shifting devices. As a result of inputting RF into one or more of the ports (1;2;3;4) a different directional beam is formed as denoted by the drawings on the right. Much similarly, figure 10 schematically presents an indoor phased array antenna.

Although the block diagram is drawn for four horizontal elements, it represents a general form of n by m antenna elements, which will be realized according to changing needs in different CWS masters. It is acknowledged that in according to one embodiment of the present invention, the antenna element is a basic radiating/receiving element and could be configured to horizontal/vertical/circular polarization. This drawing shows an example of the realization with 8 elements (4 by 2), which may produce 8 or more different beams according to the switching of the RF into the different inputs.

CLAIMS

1. A phased array antenna assembly, adapted for reducing severe radiation hazards to the human body, useful for transmitting and receiving signals while taking into account the indoor electromagnetic field strength, said antenna design comprising;
   a. micro-strip small-size antenna;
   b. switching device, having a communicating means with said antenna to select between receiving or transmitting modes, further having a selecting means for phase shift and the receiving/transmitting frequencies;
   c. a controller adapted to receive inputs from said switching device comprising;
      i. coordinating means, adapted to interconnect said switching device with a algorithm-based software; and
      ii. memory queue that records the optimal path in each indoor environment to each of the associated nodes to said antenna assembly;

   wherein said assembly is cost effective in the manner it is adapted for a indoor mass-utilization consisting of low cost materials and components, and further wherein said assembly radiate a limited electromagnetic field in a minimal measure required for communication.

2. The antenna assembly according to claim 1, wherein the indoor electromagnetic field is located in a closed construction selected from house, apartment, large vehicle, aircraft or ship, industrial space or office and further wherein said closed construction comprising a plurality of openings.

3. The antenna assembly according to claim 2, wherein the closed construction comprising obstacles selected from corridors, floors, ceiling, windows, doors or any combination thereof.

4. The antenna assembly according to claim 2, wherein the openings are selected from corridors, floors, ceiling, windows, doors or any combination thereof, and further wherein said openings are the waveguide slots.

5. The antenna assembly according to claim 1, characterized by that the path loss (L) of the electromagnetic radiation is calculated by the equation:

$$L_1 = 32.1 - 20\log_{10}\left(\chi\left|R_n\right|\right) - 20\log\left[\frac{1-\left(\chi R_n\right)^2}{1+\left(\chi R_n\right)^2}\right] + 17.8\log_{10}\left(X\right) + 8.6\log_{10}\left\{-\ln\left|R_n\chi\right| \cdot \left(\frac{\pi n}{d}\right) \cdot \left(\frac{X}{\rho_{bn}^{(0)} d}\right)\right\}$$

wherein n is the mode number; *Rn* is the reflection factor for mode number *n*, and *Kn* is the wave number for mode n.

6. The antenna assembly according to claim 5, wherein

$$R_n = \frac{K_n - kZ_{EM}}{K_n + kZ_{EM}}$$

characterized by that *Rn* is the reflection factor for mode number *n*, and Kn is the wave number for mode *n*.

7. The antenna assembly according to claim 1, characterized by that antenna creates a main beam lobe, in the manner that Pant = P0 + Pls and Pls = f(L1 *Krssi); wherein P0 – 0 dBm, and Pls – Path loss to the mobile.

8. The antenna assembly according to claim 1, wherein an ASIC protocol controls the antenna operation in the manner that the antenna is adapted to fit with any RF protocol.

9. A antenna assembly according to claim 8, wherein the ASIC comprising the algorithm of the following steps:
   i. scanning with the first beam for first station;
   ii. receiving a signal and writing the RSSI;
   iii. proceeding to next beam direction;
   iv. getting a max. RSSI or received field strength from said station;
   v. calculating the station virtual distance from the said antenna and adjusting the power level to the correct one;
   vi. registering the obtained RSSI and/or level in a memory, wherein the obtained is associated with the beam direction and with the station ID; and
   vii. scanning for a plurality of other stations as required.

10.The antenna assembly according to claim 9, additionally comprising the step of proceeding with other receiving and/or transmitting tasks.

11.The antenna assembly according to claim 8, characterized by that the calculating step is based on the electromagnetic radiation equation:

$$L_1 = 32.1 - 20\log_{10}\left(\chi|R_n|\right) - 20\log\left[\frac{1-(\chi R_n)^2}{1+(\chi R_n)^2}\right] + 17.8\log_{10}(X) + 8.6\log_{10}\left\{-\ln|R_n \chi| \cdot \left(\frac{\pi n}{d}\right) \cdot \left(\frac{X}{\rho_{bn}^{(0)} d}\right)\right\}$$

wherein *n* is the mode number; *Rn* is the reflection factor for mode number *n*, and *Kn* is the wave number for mode *n*.

12.The antenna assembly according to claim 8, characterized by that antenna used is a cell-wall socket (CWS).

13.The antenna assembly according to claim 1 or to any of its preceding claims, adapted to indoor utilization, wherein either the antenna or its associated clients are interconnected to at last one common network.

14.The antenna assembly according to claim 13, wherein the network is implemented in a plurality of closed constructions, in the manner a network of one closed construction is in communication with at least one another network located in at least one other closed construction.

15.The antenna assembly according to claim 13, wherein a master operator (CWS) is coordinating and/or communicating a plurality of sub-networks.

16. The antenna assembly according to claim 13, characterized by that while one master CWS is busy with an on-going session, selected from any fax, voice, data transaction or any combination thereof, another CWS is used as the coordinating master.

17.The antenna assembly according to claim 13, calling device will identifies itself with its personal identification number (PIN) to the CWS. The free CWS will install the PIN as the calling party number for the exchange. This will cause correct billing of the PIN owner.

18.The antenna assembly according to claim 1, characterized by a phased array antenna comprised of n by m elements with horizontal - vertical and circular polarization.

19.The phased array antenna as described in Figure 9.

20.The phased array antenna as described in Figure 10.

21.A broadband antenna assembly according to claim 1, adapted to operate at a frequency within the band gap of about 900Mhz to about 6Ghz.

22.The broadband antenna assembly according to claim 20, adapted to operate at a frequency within the band gap of about 2.4GHz to about 5.8Ghz.

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TEL. (972) 2-6518880

FIGURE 1

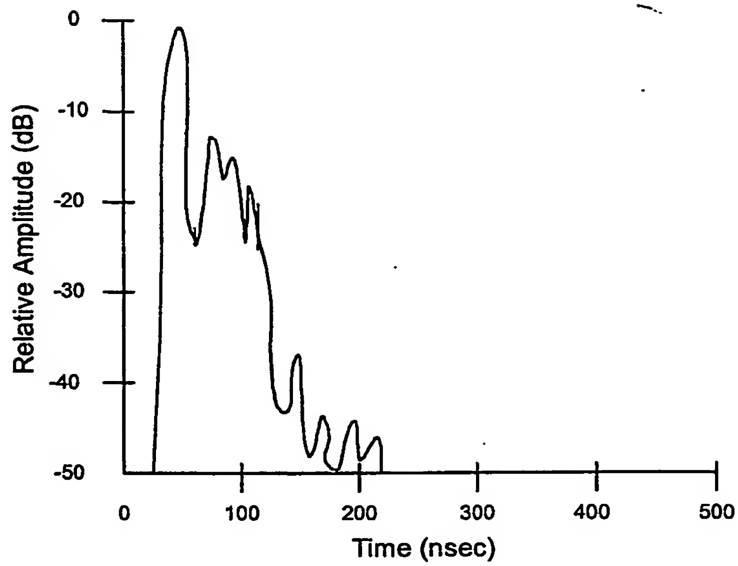


FIGURE 1A

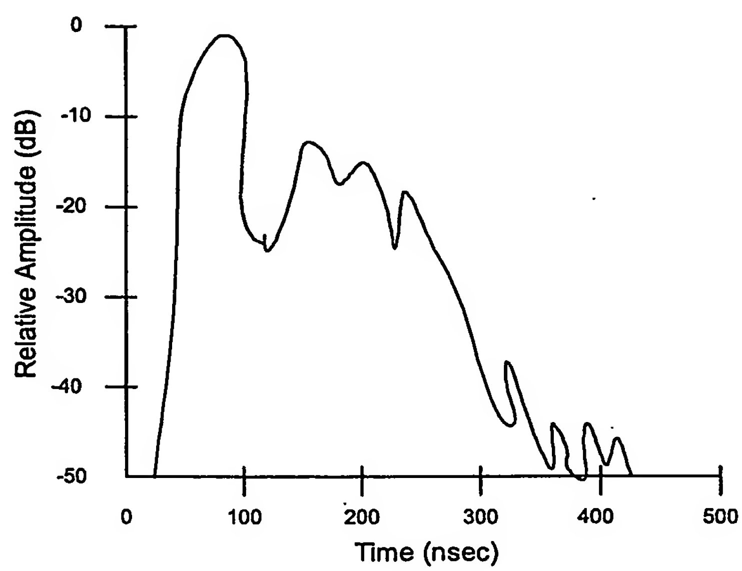


FIGURE 1B

FIGURE 2

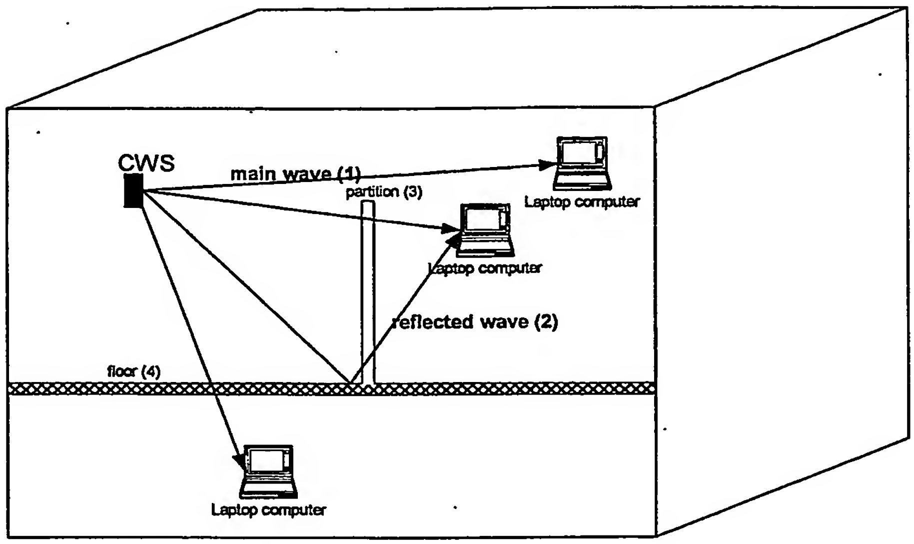


FIGURE 3

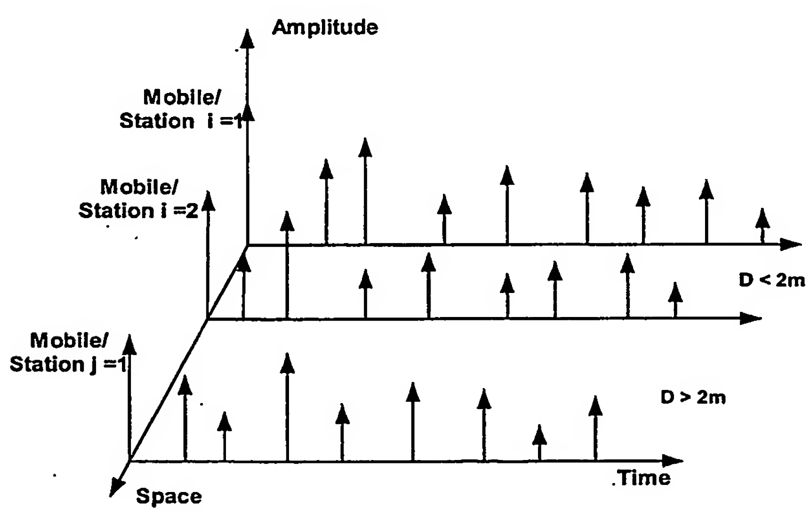


FIGURE 4

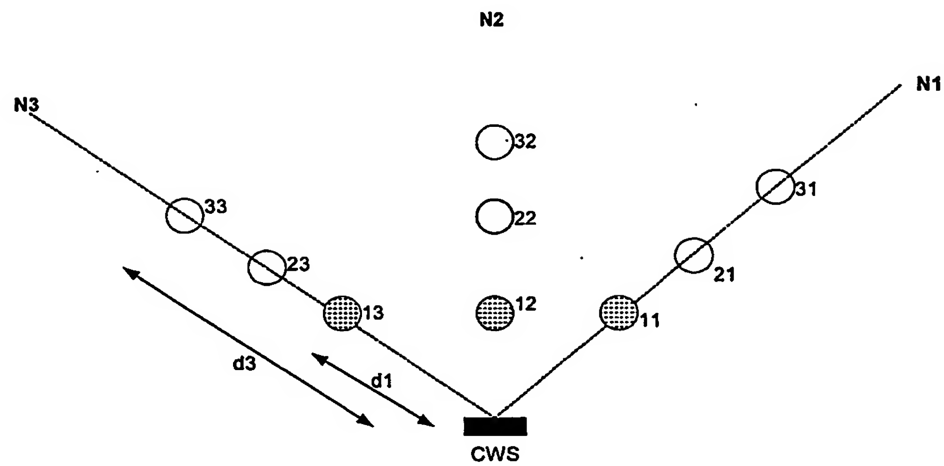
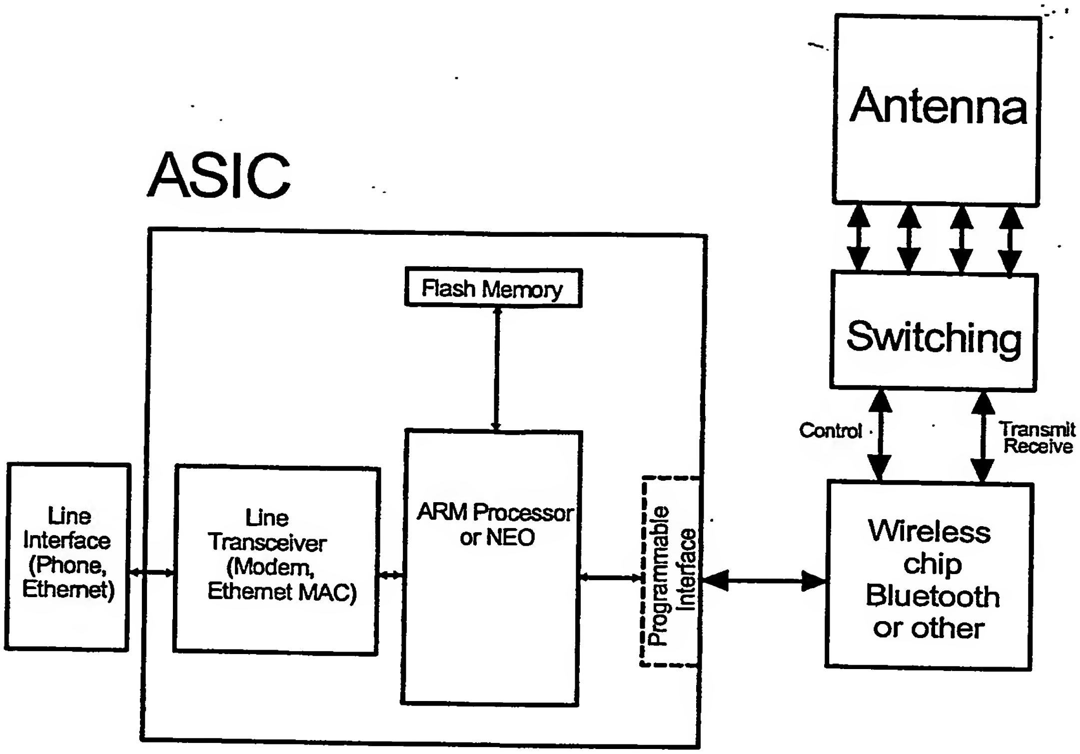
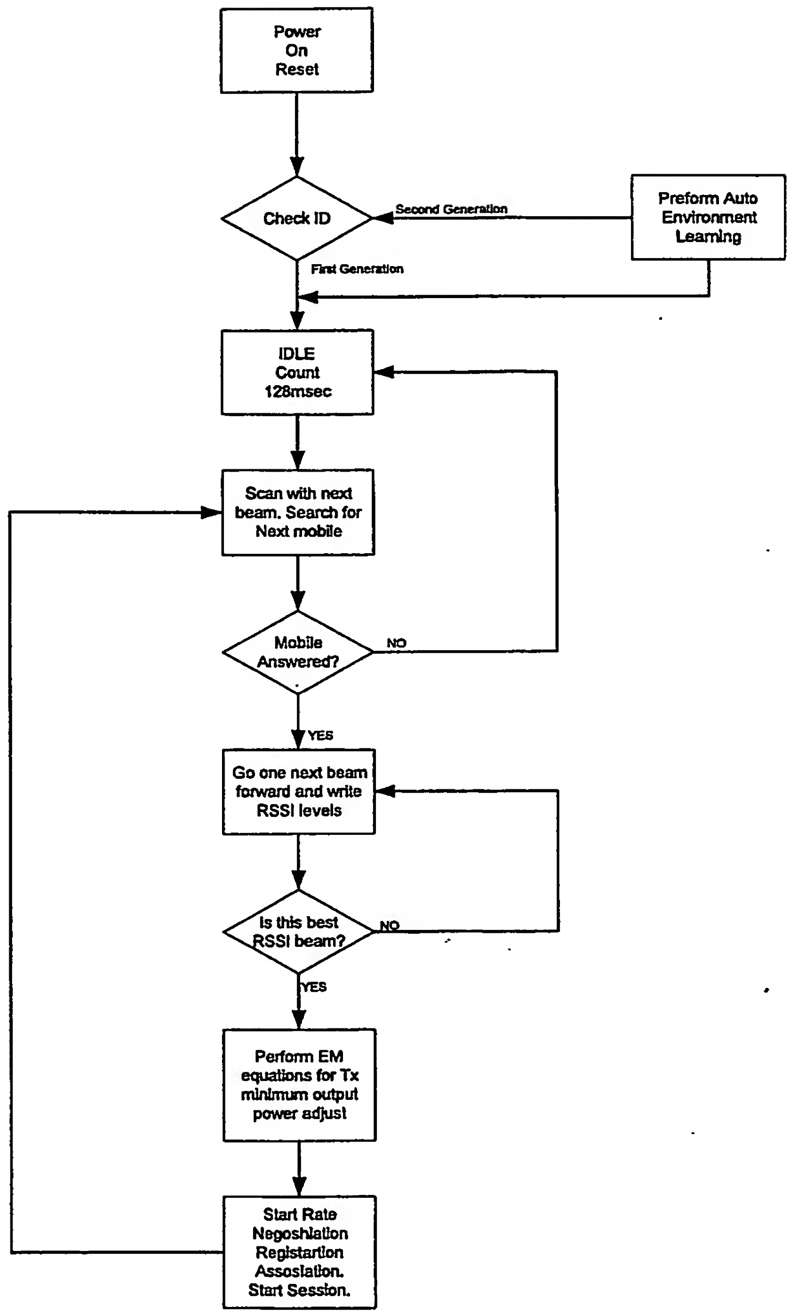


FIGURE 5



Antenna
ASIC
Switching
Flash Memory
Control
Transmit
Receive
Line Interface (Phone, Ethernet)
Line Transceiver (Modem, Ethernet MAC)
ARM Processor or NEO
Programmable Interface
Wireless chip Bluetooth or other

FIGURE 6



Power On Reset
Check ID
Second Generation
Preform Auto Environment Learning
First Generation
IDLE Count 128msec
Scan with next beam. Search for Next mobile
Mobile Answered?
NO
YES
Go one next beam forward and write RSSI levels
Is this best RSSI beam?
NO
YES
Perform EM equations for Tx minimum output power adjust
Start Rate Negoshiation Registartion Assosiation. Start Session.

FIGURE 7

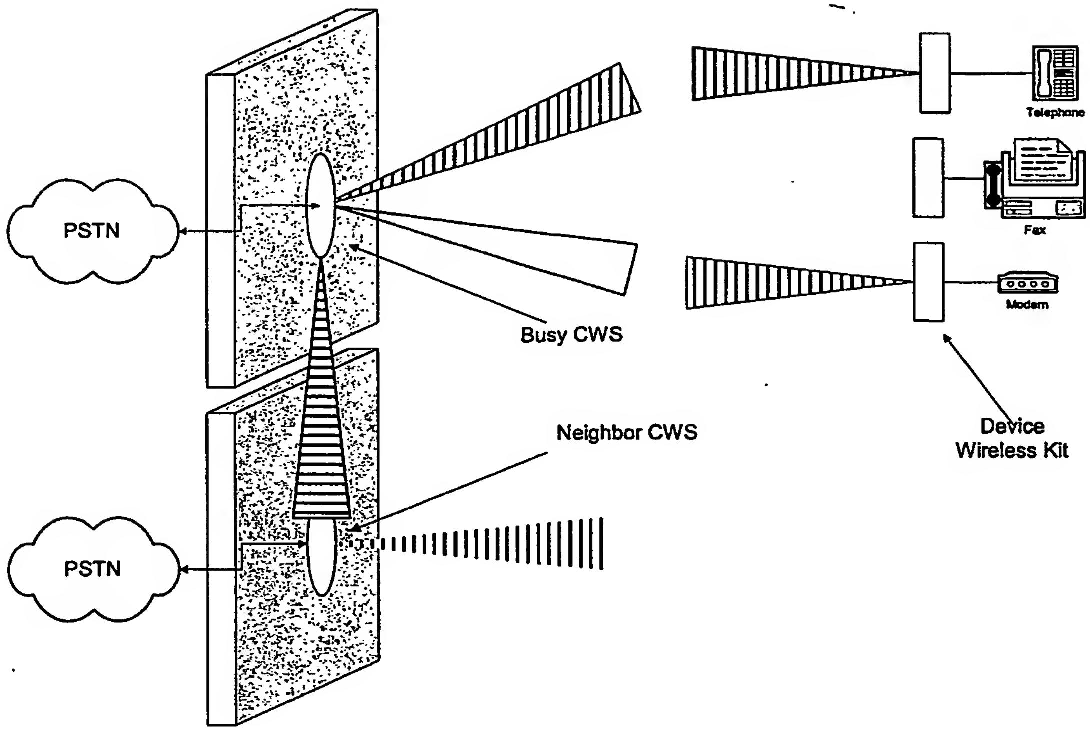
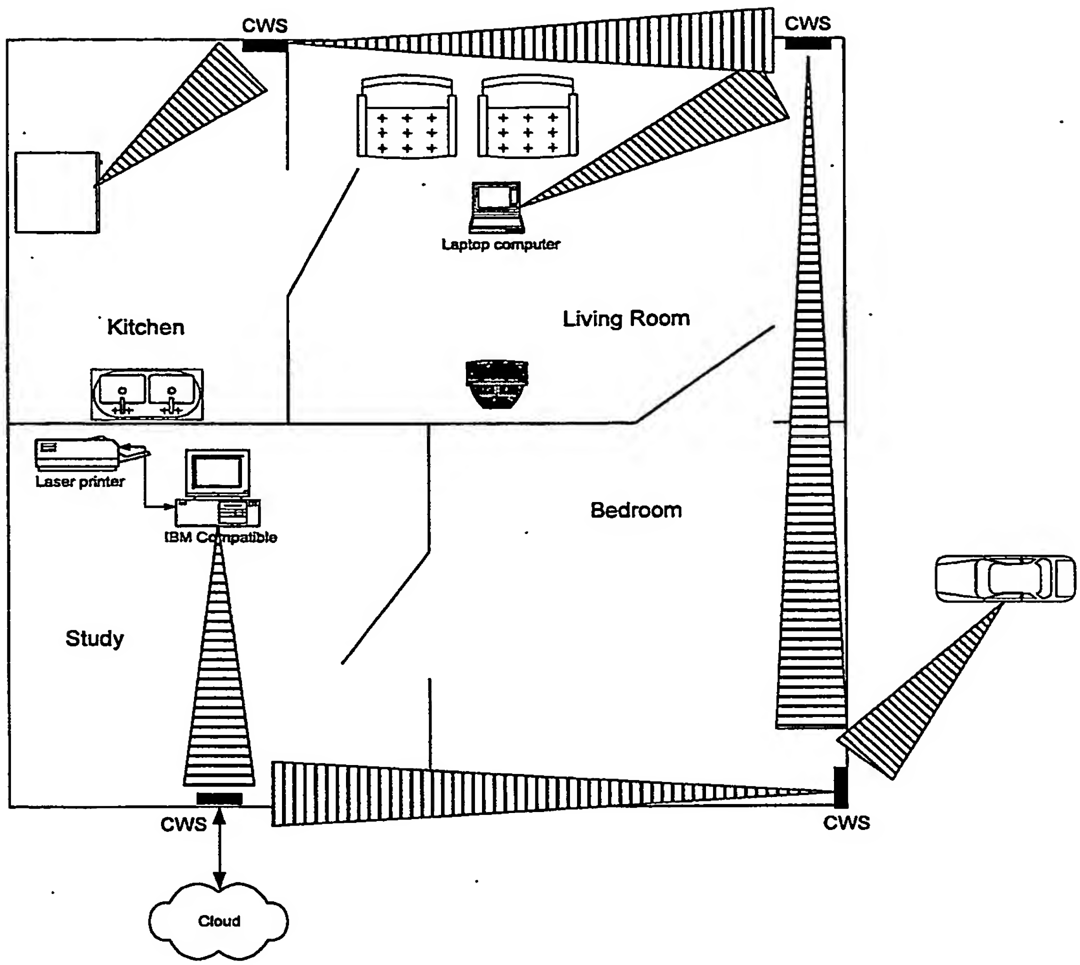
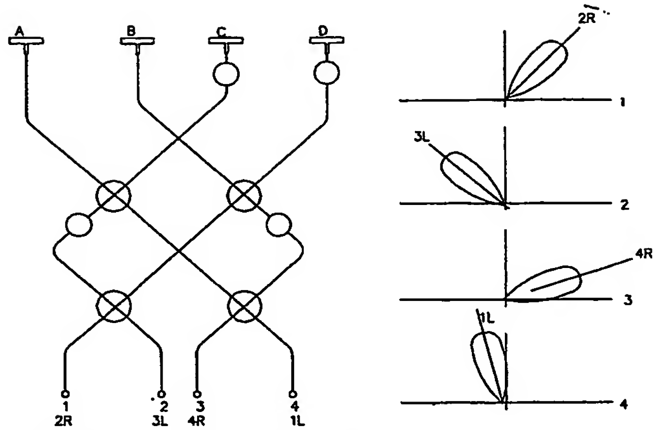

PSTN
PSTN
Busy CWS
Neighbor CWS
Telephone
Fax
Modem
Device
Wireless Kit

FIGURE 8



CWS
CWS
Laptop computer
Kitchen
Living Room
Laser printer
IBM Compatible
Bedroom
Study
CWS
CWS
Cloud

FIGURE 9



Design of BFN for 4 – Element CWS Antenna

FIGURE 10